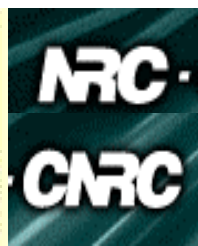
Home Smoke Alarm Tests

Experimental Overview







Overview

- **Fire Scenario Development**
- **Instrumentation**
- **Hazard Analysis**

Fire Scenario Development

- **Data origin:**
  - **John Hall from NFPA report commissioned by Linda Smith from CPSC**
  - **Data summarizes major residential structure fires according to the National Fire Incident Reporting System (NFIRS) database from 1992 - 1996**

Fire Scenario Development

- **Subsequent statistical analysis ranked scenarios by frequency of occurrence and contribution to death statistics.**

Fire Scenario Development

	Rank By Most Frequent	
1	**K F Cooking Materials**	**82,905**
2	**BR F Mattress**	**15,914**
3	K F Wire/Cable	7,499
4	**BR S Mattress**	**6,437**
5	**K FF Cooking**	**5,234**
6	BR F Wire/Cable	4,551
7	K F Interior Wall Covering	4,271
8	**LR S Upholstered Furniture**	**4,060**
9	**LR F Upholstered Furniture**	**3,715**
10	LR F Wire/Cable	3,481

Fire Scenario Development

	Rank by Most Deaths	
1	**LR S Upholstered Furniture**	**372**
2	**BR S Mattress**	**251**
3	**BR F Mattress**	**249**
4	**LR F Upholstered Furniture**	**160**
5	**K F Cooking Materials**	**142**
6	K F Clothing	79
7	LR F Wire/Cable	61
8	LR F Interior Wall Coverings	52
9	BR F Clothing	51
10	K F Structural Mem/Framing	50

Test Matrix, Laboratory Tests

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8
Fuel Package	Upholstered Furniture	Upholstered Furniture	Upholstered Furniture	Upholstered Furniture	Upholstered Furniture	Upholstered Furniture	Upholstered Furniture	Upholstered Furniture
Fire Condition	Smoldering	Smoldering	Smoldering	**Flaming**	**Flaming**	**Flaming**	**Flaming**	Smoldering
Location	Living Room	Living Room	Living Room	Living Room	Living Room	Living Room	Living Room	Living Room
HVAC On?	No	No	No	No	No	No	Yes	Yes
Sprinklers	No	No	No	No	No	No	No	No

	Test 9	Test 10	Test 11	Test 12	Test 13	Test 14	Test 15	Test 16
Fuel Package	Mattress	Mattress	Mattress	Mattress	Mattress	Mattress	Mattress	Mattress
Fire Condition	Smoldering	Smoldering	Smoldering	Flaming	Flaming	Flaming	Smoldering	Flaming
Location	Bedroom	Bedroom	Bedroom	Bedroom	Bedroom	Bedroom	Bedroom	Bedroom
HVAC On?	No	No	No	No	No	No	Yes	Yes
Sprinklers	No	No	No	No	No	No	No	No

	Test 17	Test 18	Test 19	Test 20	Test 21
Fuel Package	Grease	Grease	Grease	Grease	Upholstered Furniture
Fire Condition	Flaming	Flaming	Flaming	Flaming	**Flaming**
Location	Kitchen	Kitchen	Kitchen	Kitchen	Living Room
HVAC On?	No	No	No	Yes	No
Sprinklers	No	No	No	No	Yes

Test Matrix: Field Tests

	Test 1	Test 2	Test 3	Test 4	Test 5
Fuel Package	Upholstered Furniture	Upholstered Furniture	Upholstered Furniture	Upholstered Furniture	Upholstered Furniture
Fire Condition	**Flaming**	**Flaming**	**Flaming**	Smoldering	Smoldering
Location	Living Room	Living Room	Living Room	Living Room	Living Room
HVAC On?	No	No	Yes	No	Yes
Sprinklers	No	No	No	No	No

	Test 6	Test 7	Test 8	Test 9	Test 10	Test 11	Test 12
Fuel Package	Mattress	Mattress	Mattress	Mattress	Grease	Upholstered Furniture	Extra
Fire Condition	Smoldering	Flaming	Smoldering	Flaming	Flaming	**Flaming**	Space
Location	Bedroom	Bedroom	Bedroom	Bedroom	Kitchen	Living Room	Built
HVAC On?	No	No	Yes	Yes	No	No	In
Sprinklers	No	No	No	No	No	Yes	Here

Fire Scenario Development

- **Family Room**
  - **Flaming Upholstered Furniture**
  - **Smoldering Upholstered Furniture**
- **Bedroom**
  - **Flaming Mattress**
  - **Smoldering Mattress**
- **Kitchen**
  - **Grease Fire**

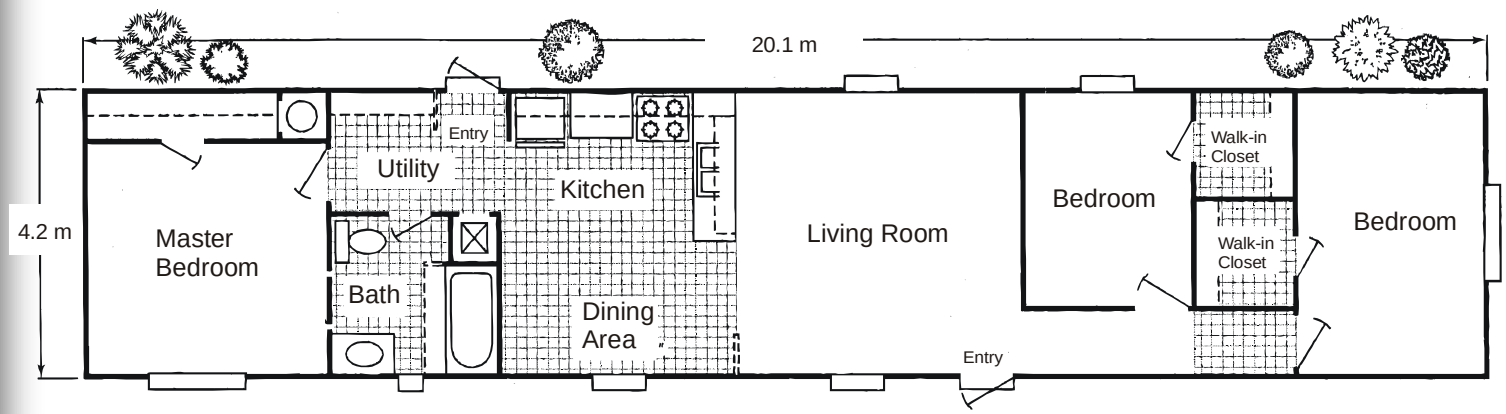
Instrumentation

- **Laboratory Tests, Manufactured Home**
- **Field Tests, 2 Story Home**
- **Instruments**
- **Instrument Locations**

Manufactured Home

- 3 Bedroom
- 1 Bath
- Kitchen
- Dining Area
- Living Room
- 902 ft^2

Manufactured Home



Field Tests, 2 Story Home

Front of House

Field Tests, 2 Story Home

Back Of House

Instruments

- **Detectors**
  - **Photoelectric**
  - **Ionization**
  - **Combination**
  - **Carbon Monoxide**
  - **Heat**
    - **Mechanical, eutectic, and rate of rise**
  - **Aspirated**

Instrumentation

- **Temperature**
  - **Small diameter, bare bead, type-k thermocouples**
- **Velocity**
  - **2-D Ultrasonic Anemometers**
    Accurate to 0.01 m/s
    Anicipated Flow: 0 – 0.5 m/s

Instrumentation

- **House Leakage**
  - **Infiltec Door Mounted Blower**

Instrumentation

- **Gas Analysis**
  - **Nondispersive Infrared (NDIR)**

    Primary Gas Analysis will Measure CO, CO_2, and O_2

  - **Fourier Transform Infrared (FTIR)**

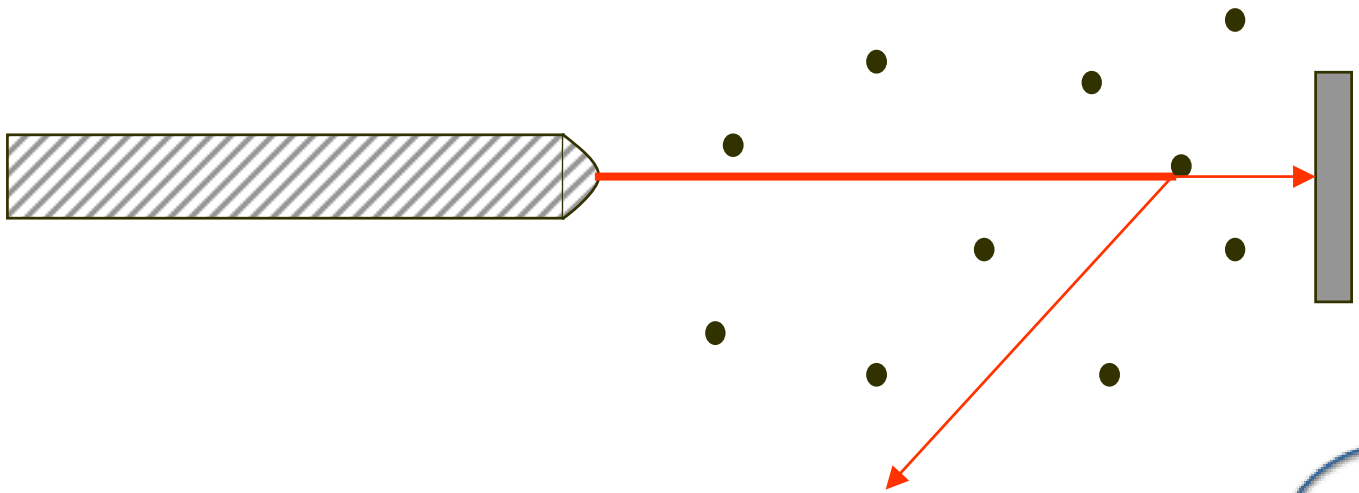
    Secondary Gas Analysis will Measure HCl, HCN, NOx, HBr, and HF

Instrumentation

- **Mass Loss Rate**
  - **Floor Mounted Load Cell Apparatus**
- **Sprinkler Response**
  - **Code Compliant 13-R Domestic Sprinkler Heads, Partially Charged**

Instrumentation

- **Smoke Obscuration**
  - **Laser-based light extinction measurements**



Instrumentation

- **Tapered Element Oscillating Microbalance (TEOM)**

Temporal Mass Flux

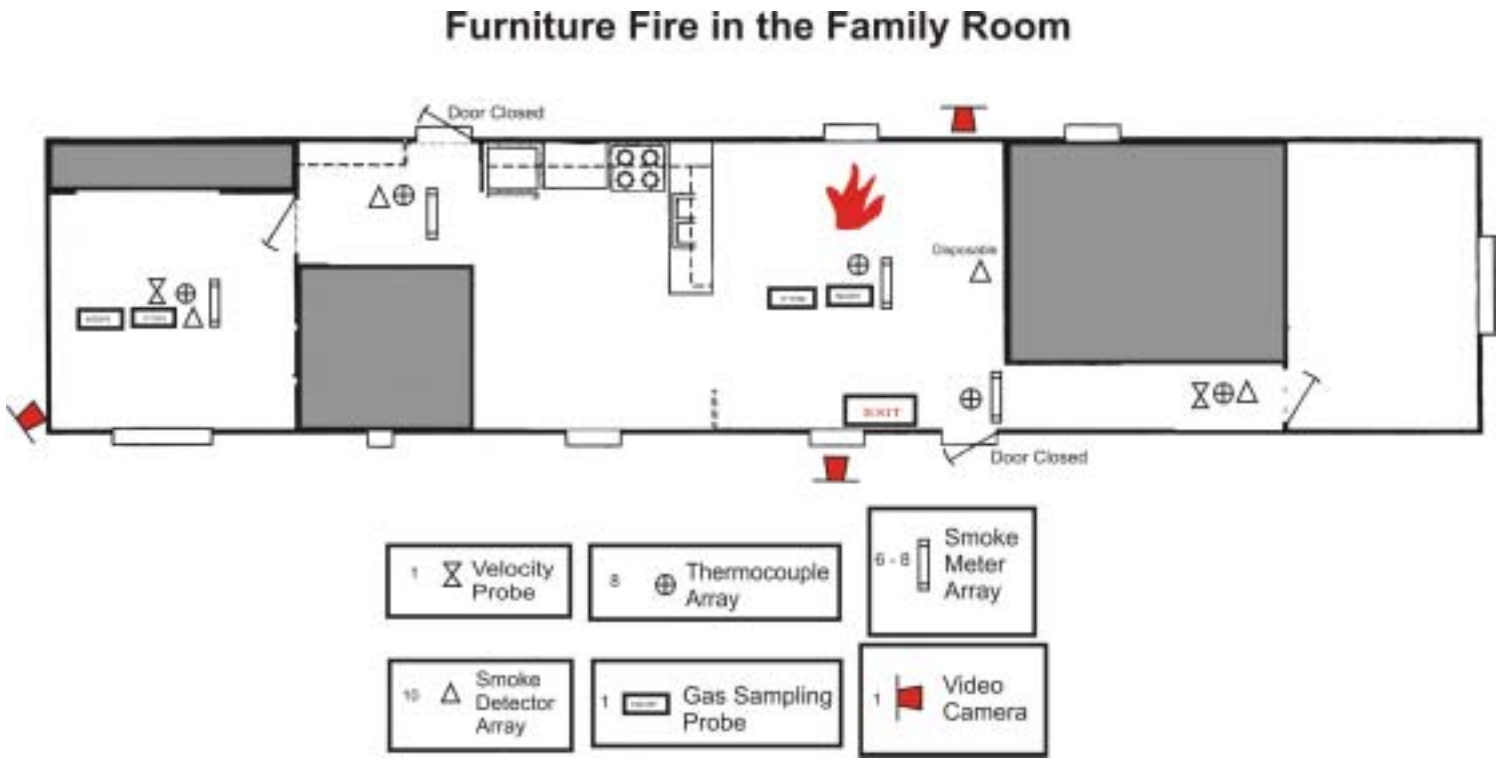
- **Cascade Impactor**

Geometric Distribution

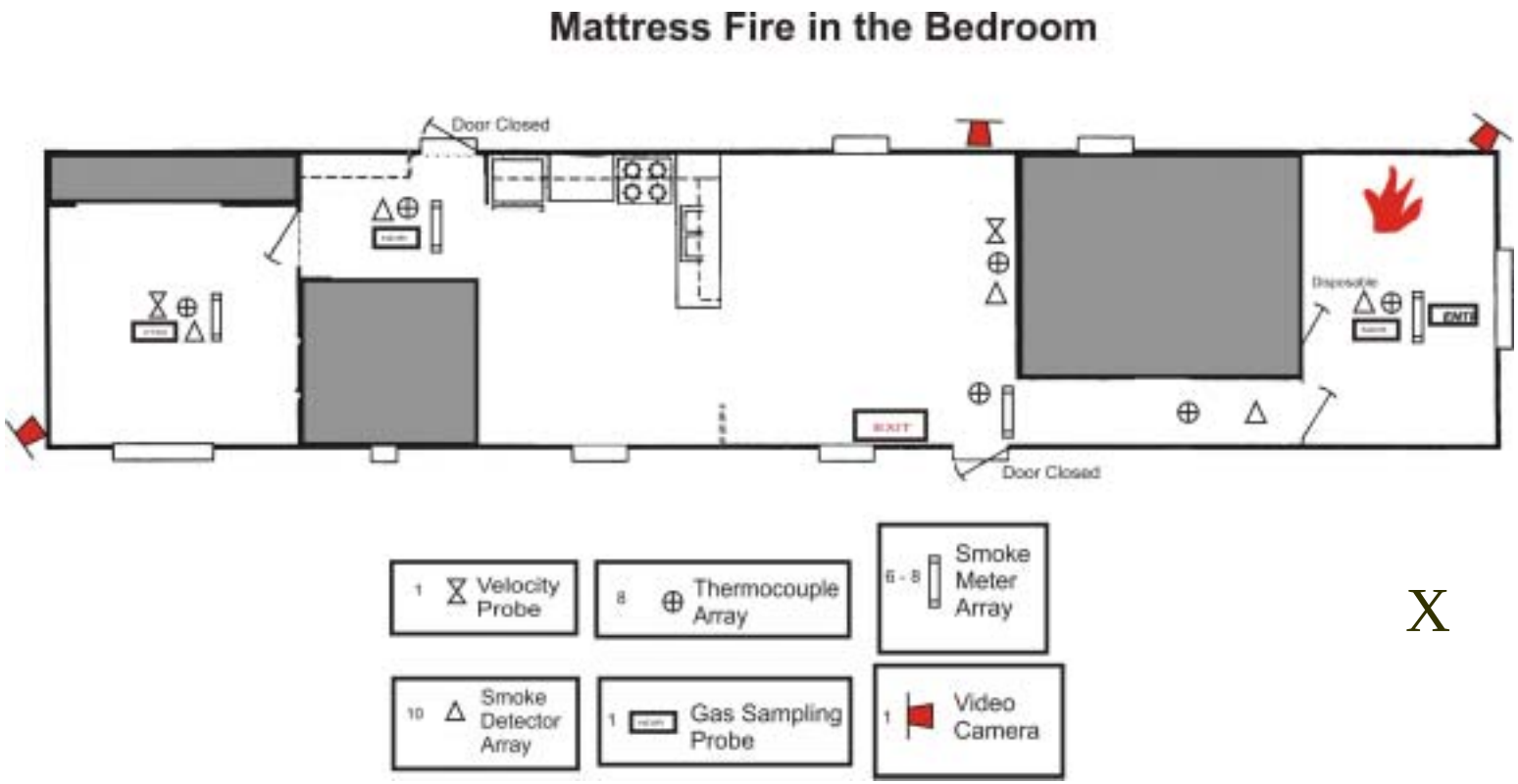
Instrumentation

- **Video Recording**
  - **Room of Origin**
  - **Target Room**
  - **Primary Exit**

Instrumentation



Instrumentation



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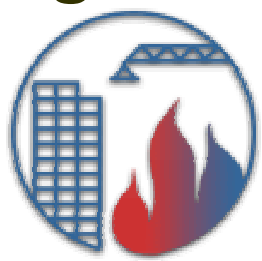
What do we do with All this data?

Hazard Analysis

- **Primary Objective**
  - **Quantify the time available to residential occupants to escape a fire**
- **Key Measurements**
  - **Time to occupant notification (typically detector activation)**
  - **Time to untenable conditions along the egress path**



Hazard Analysis

- **Detector Activation**
  - **Analog signals allow posteriori analysis of multiple alarm criteria and algorithms**
  - **Capabilities and shortcomings of various detection technologies can be compared**

Hazard Analysis

- **Tenability Criteria**
  - **Elevated Temperature**
    - **65°C at a layer height of 1.5 m**
  - **Smoke Obscuration**
    - **OD ≥ 0.25 m^{-1} at a layer height of 1.5 m**
  - **Convected Heat**
    - **Purser hyperthermia equation**

Hazard Analysis

- **Tenability Criteria (cont'd)**
  - **Toxic Gases**
    - **Fractional Incapacitating Dose from Purser for CO, HCN, O_2, and CO_2**

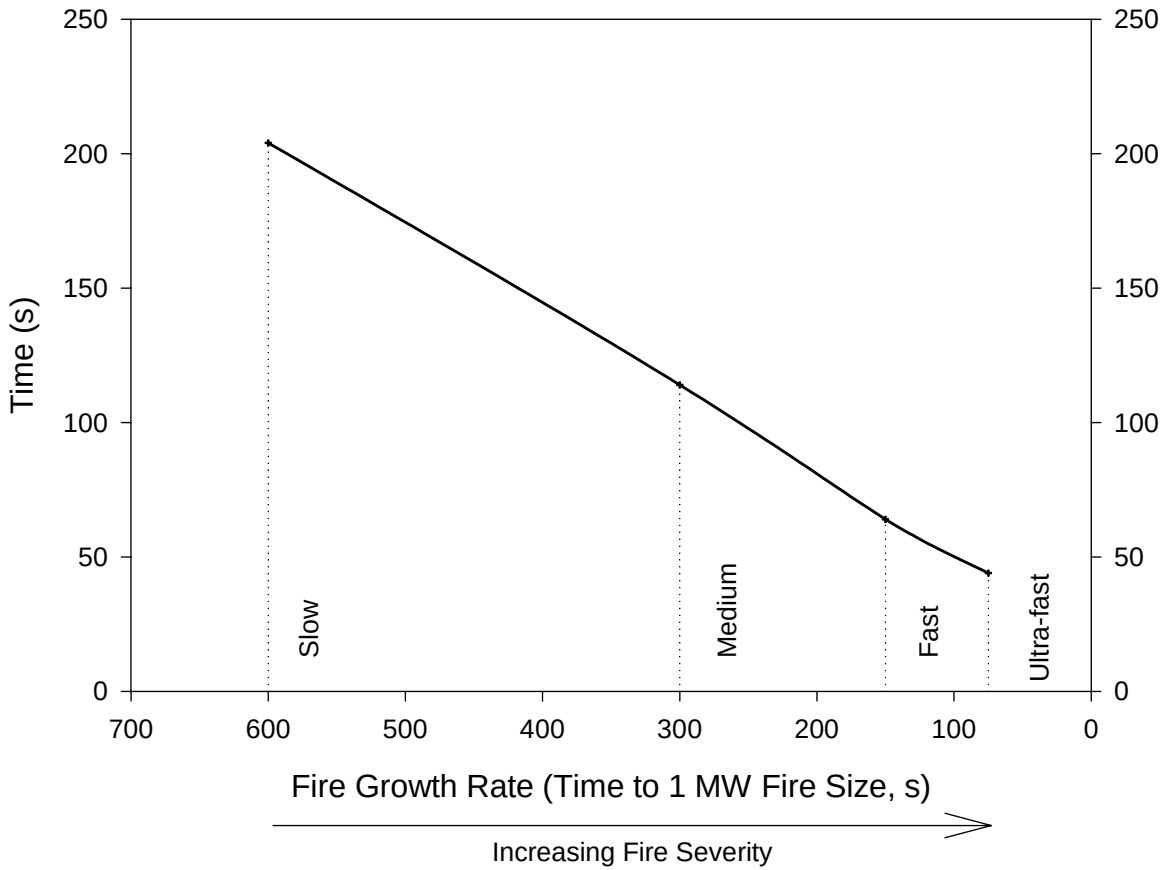
Hazard Analysis

- **Fire Modeling**
  - **Fire Dynamics Simulator (FDS)**
    - **Computational Fluid Dynamics model which uses the Large Eddy Simulation (LES) method to simulate fire phenomena**
  - **Used to both plan manufactured home and off-site experiments, as well as further analyze the experimental results.**

Fire Dynamics Simulator

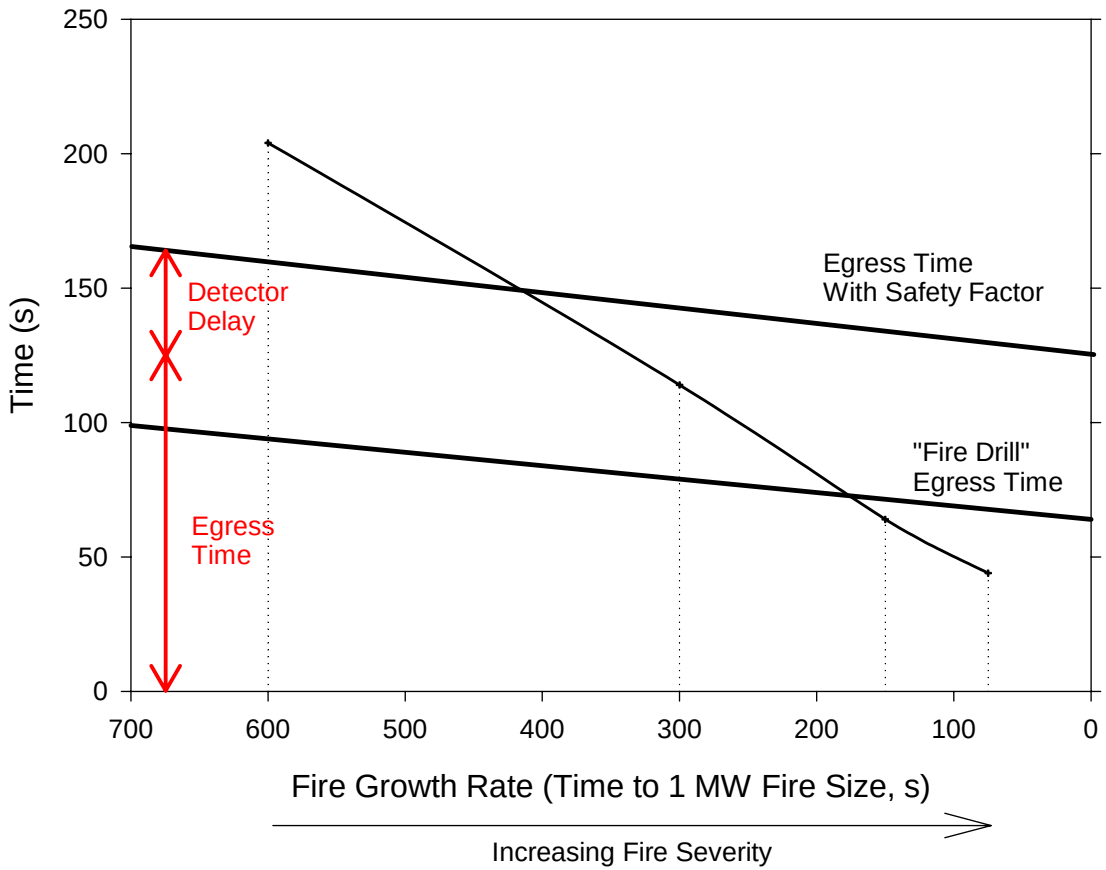
Hazard Analysis

- **Fire Performance Curves: Baseline**



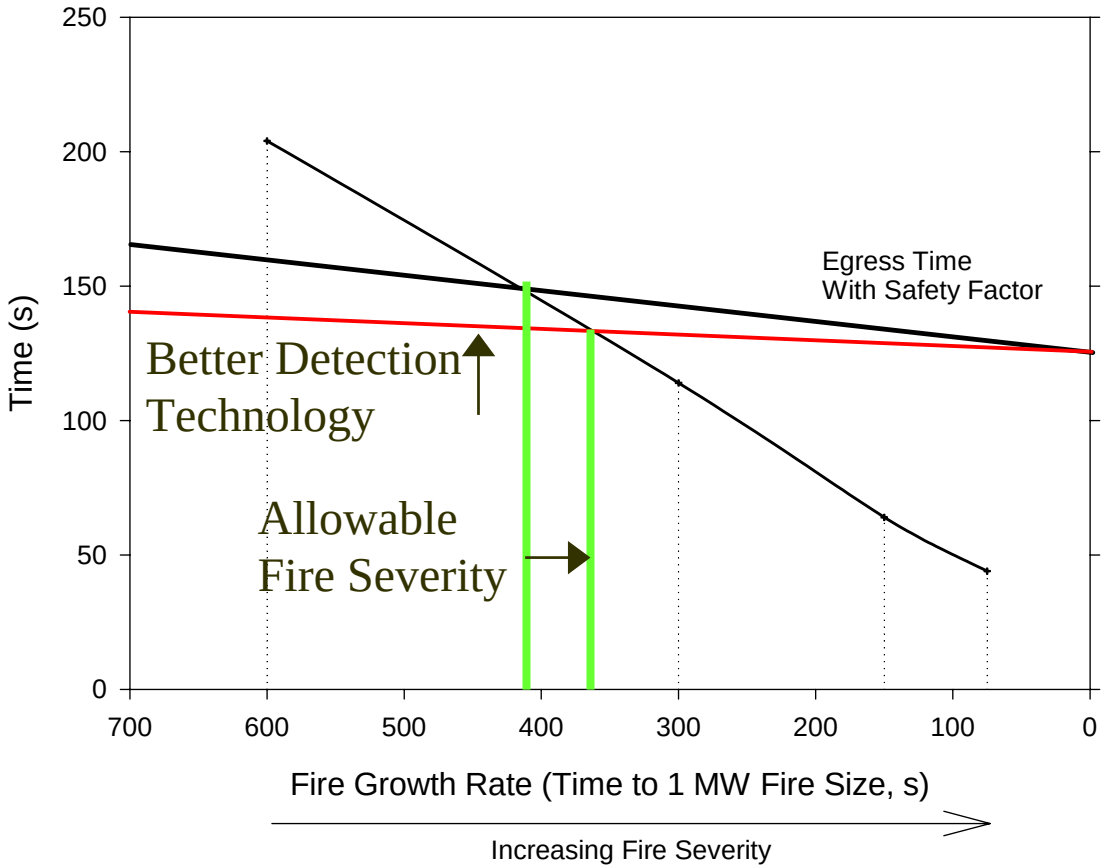
Hazard Analysis

- **Fire Performance Curves: Egress**



Hazard Analysis

- **Fire Performance Curves**



Questions?